Data Assimilation and Model Simulations in the California Current

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LONG-TERM GOALS

The long-term goal of my research is to develop, verify, and apply numerical ocean prediction models to eastern boundary coastal regions in order to improve our scientific understanding of the structure and dynamics of such regions.

OBJECTIVES

The broad objective of this research is to aid in the development of a reliable modeling capability for eastern boundary current regions. My specific objective is to carry out and extensively verify several DieCAST model simulations of the annual cycle in the California Current. I also wish to evaluate and apply digital filter initialization (DFI) as a diagnostic tool in numerical ocean prediction.

APPROACH

I intend to carry out increasingly complex numerical simulations of the California Current using the DieCAST regional model. I will then verify the simulations against ONR's extensive eastern boundary current (EBC) data sets. I also intend to evaluate iterative versions of digital filter initialization (DFI) as a diagnostic tool for ocean analysis, and then apply the method to several quasi-synoptic hydrographic data sets from the California Current and the Alboran Sea. Results from the California Current will be compared with those obtained using the iterated geostrophic method (IGM, Allen 1993) and the results from the Alboran Sea will be verified using direct measurements of the vertical velocity determined by quasi-isobaric RAFOS floats.

WORK COMPLETED

I have adapted the DieCAST A-grid, low-dispersion (4th order) regional model (Dietrich 1997) to the California coastal domain and completed two six-year long numerical simulations. Lateral boundary conditions are prescribed from monthly climatological data and from a global ocean model simulation. One of the simulations uses a climatological annual cycle of wind stress forcing, while the other simulation includes an additional, idealized wind stress enhancement near each coastal headland representative of observations (e.g., Enriquez and Friehe 1995; Rogers et al. 1998). Preliminary results

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have been published in an NPS Masters Thesis (Donato 1998), while a complete analysis of the simulations is still in progress.

I have applied iterative forms of DFI to several idealized test cases and have determined an optimal version of the method for use in diagnostic studies. DFI is now being applied to data sets from the California Current (ONR's CTZ and EBC programs) and the Alboran Sea (EC's OMEGA project).

I contributed to two studies of the Alboran Sea that were published this year, and I collaborated in a study of stochastic resonance in the thermohaline circulation that we recently submitted for publication.

RESULTS

Using climatological forcing, our DieCAST model simulation reproduces many of the main features of the observed annual cycle of the California Current including the strengthening of the coastal jet in spring and the weakening of the jet in autumn and winter. Coastal eddies in the simulation form primarily off the major headlands, especially Cape Mendocino and Point Arena. As a result, a region of maximum eddy kinetic energy (EKE), originally formed in the upper ocean over the continental slope in late spring, migrates westward on a seasonal time scale. At the same time, the EKE spreads vertically into the deep ocean, decreasing the EKE west of about 126W. This result identifies a non-dissipative process that can account for the pronounced decrease of surface EKE west of 126W recently documented in the literature (Kelly et al. 1998, Strub and James 1998). The additional forcing by the headland wind jets is found to produce both local and remote changes to the simulated annual cycle.

The optimal form of DFI was shown to be able to diagnose the 3-dimensional circulation and vertical velocity in an idealized growing baroclinic frontal wave with a relative accuracy greater than 90%. At the same time, it is shown that accurate measurements of the currents are needed in order to diagnose the mesoscale circulation on space scales as short as the Rossby radius. Using DFI, a closed cyclonic eddy observed off Point Arena California was diagnosed to exhibit relatively small vertical velocities on the scale of the eddy itself, but to have very significant vertical velocities ($w \sim 30$m/d at 100 m) associated with sub-eddy scale meanders in the otherwise circular flow around the eddy.

In the Alboran Sea studies, we used remotely sensed and in situ data to document a new mode of synoptic scale variability in the Western Alboran Gyre and to interpret the variability dynamically. In our thermohaline circulation study we showed that a small periodic variation in the fresh water fluxes, as small as 5% of the mean fresh water flux, in the presence of background variability (noise), can induce quasi-periodic transitions between two stable states of the thermohaline circulation.

IMPACT/APPLICATIONS

Our California Current annual cycle simulations are among the most advanced ones to date. Because of the excellent observational data sets being used, the model verifications will represent the standards against which other models will be evaluated in the future.

TRANSITIONS

Our research on data assimilation and simulations in the California Current is in broad support of the efforts at FNMOC (M. Clancy) and NRL-Stennis (J. Kindle) to develop a real-time ocean analysis and forecasting capability, including biology, for this region. This support manifests itself in close coordination, and timely information exchange on such topics as model properties, experimental set-up, forcing data, regional modeling difficulties, comparison and exchange of results, methods of model verification, and so forth.

The DFI methodology has been accepted as the major diagnostic tool for estimating the ageostrophic circulation and vertical motion in the EC-sponsored OMEGA project. This multinational European project completed six quasi-synoptic oceanographic surveys in the western and central Mediterranean last year.

RELATED PROJECTS

I am collaborating with J. Barth (OSU) in his application of the DFI diagnostic method to the EBC synoptic survey data.

I am collaborating with D. Dietrich (MSU-CAST) in a DieCAST model hindcast of the Santa Barbara Channel driven by high resolution wind stress data from COAMPS. I am also providing the COAMPS wind stress data to Leo Oey for a similar SBC hindcast using the Princeton Ocean Model (POM).

I am collaborating with A. Viudez and J. Tintore (UIB, Spain) in diagnostic studies of mesoscale variability in the Alboran Sea and modeling studies of climatic variability of the thermohaline circulation.

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